Assessment of Older Corroded Pipelines with Reduced Toughness and Ductility Project 153L

2nd QUARTERLY PUBLIC REPORT

Consolidated Research and Development Program to Assess the Structural Significance of Pipeline Corrosion

Period: July through September 2005

Background

Metal loss due to localized corrosion and pitting of pipelines can significantly increase the risk of rupture. Therefore, it is vitally important to accurately determine the residual strength of corroded pipelines so that proper remedial actions may be taken to avoid catastrophic events. Although historical methods and practices for inspection and integrity assessment have led to an overall safe and reliable pipeline infrastructure with a low frequency of failures, public expectations concerning pipeline safety are growing, and industry is committed to pursuing further improvements. Consequently, new US regulations and sophisticated inspection technologies have burdened many operators with large quantities of data that are often difficult to interpret and apply within the framework of existing assessment guidelines. Clearly, the industry needs a technically sound, comprehensive and integrated approach to assess and mitigate the effects of localized corrosion in gas and oil pipelines, and to assure appropriate pressure-containment safety margins.

Several methods have been developed for assessment of corrosion defects, such as ASME B31G, RSTRENG and LPC. These methods were developed using an early fracture mechanics relationship for toughness-independent failure of pressurized pipes and were empirically calibrated against a database of full-scale burst tests for thin wall pipes. Some work has already been done to address the limitations of existing assessment methods available to the industry. The objective of this project is to develop guidance on the use of existing failure criteria for corroded linepipe operating in the ductile/brittle transition regime.

Summary of Progress this Quarter

Finite element models of ring expansion specimens and vessels with various corrosion type defects have been analyzed using ABAQUS. The rings and vessels modeled have been tested in a previous PRCI project test program (PR-273-0136). Five separate non-linear finite element (FE) runs have been carried out for each geometry with elastic-plastic material properties corresponding to temperatures of -60, -40, -20, 0 and +20 deg C. Material properties at these temperatures have been interpolated from the tensile tests undertaken at -60 deg C and at room temperature. Internal pressure has been applied in several load increments up to a maximum load exceeding the burst pressure measured during testing. The results at each load increment have been post processed to calculate the Weibull stress corresponding to the particular temperature and internal pressure at each load increment. The Weibull stress results enable calculation of the internal pressure corresponding to a 5% probability of failure by a brittle mechanism for each temperature of interest. As a result, a curve defining the hoop stress at which a 5% probability of brittle failure is expected has been produced for each ring specimen and vessel investigated. This 5% probability curve can be compared with existing methods for failure pressure prediction of corrosion defects such as RSTRENG and LPC-1. This approach allows an effective transition temperature to be defined as the intersection between the 5% probability and RSTRENG / LPC-1 lines, at which point RSTRENG is no longer conservative. The method also enables investigation of the effects of defect acuity and depth on the effective transition temperature.

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Results

Figures 1 through 5 below are examples of FE analysis and post processing results. These figures are of the analysis and post processing results for the Finite Element Analysis for a 50% depth notch defect.

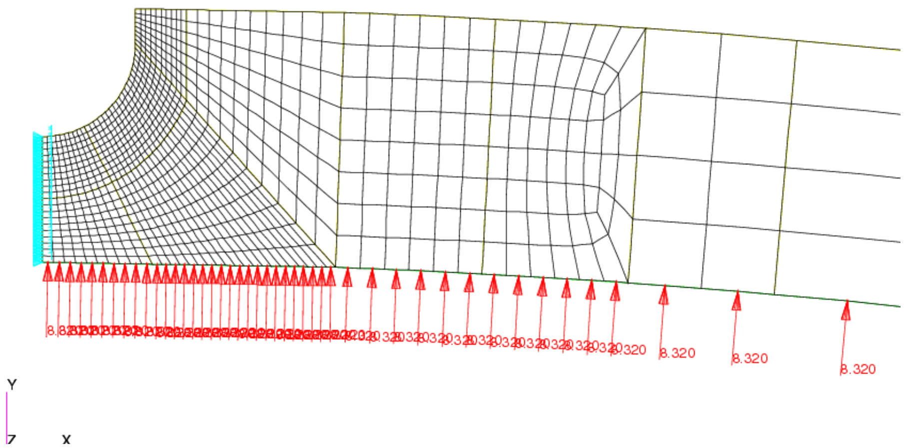

Figure 1: Mesh and boundary conditions

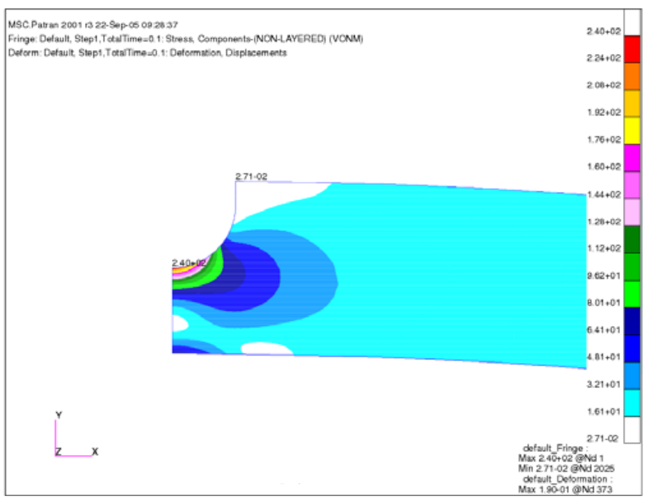

Figure 2: Von Mises stress at 10% load

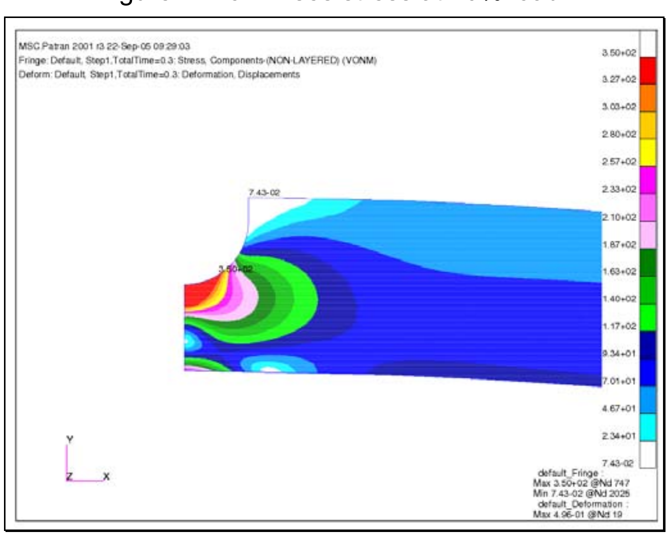

Figure 3: Von Mises stress at 30% load

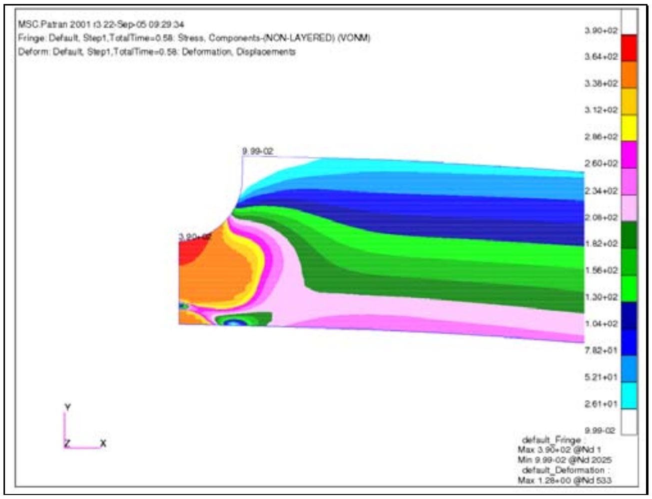

Figure 4: Von Mises stress at 58% load

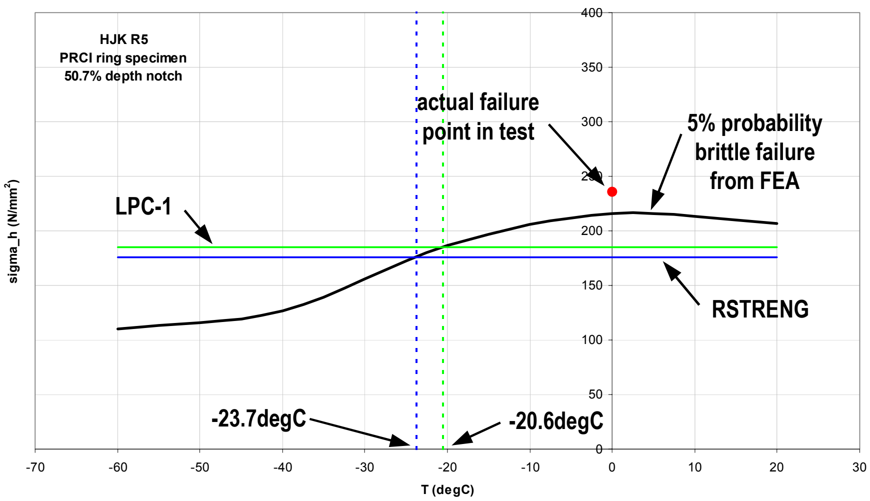

Figure 5: Post processing results and interpretation of 50% depth notch defect FEA

Future Activities

Work over the next quarter will focus on completing the testing of notched round bar tensile specimens from a low toughness pipe at low temperature to assess failure characteristics of corrosion defects, ring expansion tests at 0 degrees C with machine defects, and the Finite Element analysis and assessment.

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